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When men appear smaller or larger than they really are: preliminary evidence that women are fooled by size illusions in attractiveness judgment tasks

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Abstract: In humans, studies have shown that contrast illusions can affect perceptions of facial attractiveness and dominance. In non-human animals, recent research found that contrast illusions of size positively affected male mate value. In humans, male height is a potentially important indicator of mate value, with women preferring men taller than themselves. We tested in two studies whether height contrast illusions could affect women's perceptions of male height and mate value, particularly attractiveness, dominance, and muscularity. Using computer-generated images of men of different heights standing in groups of three, 104 female participants rated targets either surrounded by shorter, same height, or taller distractors in a within-subject design. The second experiment (N=80) replicated and extended the first by making the images more realistic and adding natural backgrounds, suggesting that when participants are given a visual anchor, in order to get a better sense of the absolute height of the targets, the effects remain. In both studies, results showed that, compared with same height distractors, male targets were rated as taller when surrounded by shorter distractors, and as shorter when surrounded by taller distractors. Additionally, attractiveness, dominance, and muscularity perceptions were affected in a similar manner, with most of the differences in these appraisals being mediated by the perceived height differences. Therefore, differently sized distractors affected the perceived height and mate value of the targets, which were in effect all of the same constant size. These findings indicate that context dependent effects could potentially influence attractiveness judgments. The same man might thus be perceived as more attractive when surrounded by men of similar or smaller height, as opposed to when surrounded by men who are taller.

Key words: mate value, visual illusion, contrast illusion, mate preferences, Ebbinghaus illusion

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Introduction

Body size is among the most commonly studied traits in non-human animals in evolutionary biology, for example with regards to: assortative mating (e.g., Jiang et al. 2013), sexual selection (e.g., Fairbairn 1997), speciation (Nagel and Schluter 1998), life history theory (Isaac 2005), etc. In humans, height has also been the focus of much research by evolutionary scholars, dating back to Galton (1886) and Pearson (1895), as it is an easily measurable trait, which is (highly) heritable (e.g., Silventoinen 2003; Silventoinen et al. 2003, 2008; Visscher et al. 2006). While the sexual dimorphism in stature in humans is relatively small, it seems to be consistently present across human societies (Wells 2012). Height is also consistently related to reproductive success, albeit differently across cultures and between the sexes (reviews in Sear 2010; Stulp et al. 2012b-c). As there could be different selective pressures operating on height for each sex, this opens up the possibility that height is subject to sexually antagonistic selection (Stulp et al. 2012a). Given the importance of height for sexual selection in humans, it is important to further understand how mate preferences for height operate.

In Western societies, height has been consistently found to be important for heterosexual mating preferences (e.g., Beigel 1954; Courtiol et al. 2010; Gillis and Avis 1980). While men appear to be more 'flexible' in their height preferences for their female partners, women seem to be more restrictive, showing a smaller range of preferred and acceptable height in their partners than men (Stulp et al. 2013b). Many different processes can underpin and shape preferences for height. Firstly, since the studies by Pearson (Pearson 1895; Pearson and Lee 1903), researchers have documented evidence for assortative mating: taller individuals prefer a taller partner and shorter individuals prefer shorter ones (e.g., Courtiol et al. 2010; Fink et al. 2007; Pawlowski 2003; Spuhler 1982; Stulp et al. 2013b-c). Next, a male-taller norm has been argued to exist in Western societies: women prefer men taller than themselves, and men prefer women shorter than themselves (Beigel 1954; Courtiol et al. 2010; Gillis and Avis 1980; Pierce 1996; Stulp et al. 2013b-c; Swami et al. 2008), although women seem to prefer a larger size difference than men do (Stulp et al. 2013b). However, the preferred size difference also has a limit, 'the male-not-too-tall norm' (Stulp et al. 2013c), and in addition appears to be conditional on the woman's height ('Pawlowski rule'; Fink et al. 2007; Pawlowski 2003; Salska et al. 2008). It is important to note that some of these preference rules might arise as a consequence of another rule, for example enforcing (strict) assortative mating will give rise to a male-not-too tall norm as well as a male-taller norm (Stulp et al. 2013c). Finally it is important to note that observed or stated preferences have been found to translate in actual pairings (Stulp et al. 2013c), though the relationship between (stated) preferences and pairings can be weak (e.g., in a speed dating context, see Stulp et al. 2013a). For height, studying preferences might therefore provide us with some insight into mate choice, although many other processes might also influence the degree to which these mate preferences might not translate into mate choice (see for example, Cotton et al. 2006; Johnstone et al. 1996).

Next to associations with female mating preferences, male height is also ar-

gued to be positively related to two other interpersonal factors, namely dominance and status, terms which are often used synonymously in literature (e.g., Marsh et al. 2009, but see Henrich and Gil-White 2001). The relationship between height and dominance/status appears to operate in both directions. When targets were framed to be of a higher status, e.g., by showing them in high status and dominant poses (Marsh et al. 2009), or by making them out to be of a higher rank or authority status (Dannenmaier and Thumin 1964; Wilson 1968), they were perceived as taller when their ascribed status was high as opposed to low. Conversely, when targets were presented as taller, their perceived status (Marsh et al. 2009), dominance (Blaker et al. 2013; Montepare 1995), and strength (Sell et al. 2009) increased compared to shorter targets. Interestingly, not only do perceptions of others change with regard to height, men with a high status overestimate their own height more than men of lower status (Duguid and Goncalo 2012). Taller men also show a higher level of interpersonal dominance than shorter men (Stulp et al., submitted). Relatedly, satisfaction with one's own height is positively related to actual height, and more so for men than women, in that satisfaction increases with height, until at least average height is reached (Stulp et al. 2013b). While there was no difference between average and above-average height, it seems that it is important to at least not be shorter than others, on average (also see Stulp et al. 2014).

As dominance (Sadalla et al. 1987) and muscularity (Frederick and Haselton 2007) have been shown to increase male attractiveness (although in a similar way as with height, attractiveness decreases again if muscularity is too extreme), and male status is suggested to positively correlate with women's willingness to engage in a relationship (e.g., Buss 1994; Miller 2000; Townsend and Levy 1990), in the present research ratings of attractiveness, dominance, and muscularity are all assumed to be indicators of potential 'mate value'. We therefore only refer to some physically observable aspects of mate value, which can be defined as the extent to which a given individual could increase the reproductive success of another individual by mating with that person (Sugiyama 2005).

While adult men are unable to influence their actual physical height, *perceptions* of their height can of course be manipulated. Our minds can even be tricked into believing that people and objects are of a different size while they are not. One popular example of how our minds can be tricked is the Ebbinghaus illusion, in which two objects of the same size are presented next to each other, where one is surrounded by larger objects and the other by smaller objects (Ebbinghaus 1902). This creates the illusion that the one surrounded by smaller distractors is larger than the one surrounded by larger distractors. This neighbor effect has been shown to affect mate value in non-human animals. Callander et al. (2012) found that male attractiveness in the fiddler crab, which is positively related with size, was increased if a same-sized crab was immediately surrounded by smaller crabs, compared with larger crabs. Generally, these types of contrast effects do not have to be size related for the illusion to work (for reviews, see Bateson and Healy 2005, and Kelley and Kelley 2014). For example, in guppies, where male attractiveness is positively related with the degree of coloration, females choose the males that look more colorful in compar-

ison to others. More importantly even, male guppies use this to their distinct advantage, by positioning themselves next to less colorful males if a female is present, to increase their own attractiveness and mate potential (Gasparini et al. 2013).

In humans, not much research has been conducted thus far to examine contrast illusions in mate choice. Research on mate preferences for faces showed that target faces were rated as more attractive when surrounded by less attractive faces, compared to when surrounded by more attractive flankers (Little et al. 2011). Similarly, Re et al. (2014) found that faces were perceived as more dominant when they were surrounded by less dominant faces, compared with more dominant faces. Bateson et al. (2014) were the first to examine the contrast illusion with regard to mate preferences for body size. As physical size, measured by body mass index (BMI), is a key predictor for ratings of physical attractiveness in women, they tested whether creating a size illusion would change the perceived attractiveness of female targets. However, while the participants did perceive the women surrounded by larger distractors as thinner than when surrounded by thinner distractors, the perceived attractiveness did not differ significantly between conditions.

As argued above, male height plays a large role in human mate preferences and choice. No research has yet been conducted to examine if contrast illusions can alter perceived height in men, and whether this could have an impact on the perceived attractiveness. The studies in this paper are, to our knowledge, the first to investigate contrast illusions for height in men. Following Bateson et al. (2014), we hypothesized that based on the contrast illusion, a medium sized target would be rated as taller when surrounded by short distractors, compared with large distractors. When the target is surrounded by same-sized distractors, no size illusion should occur and the height rating of this target should fall in between the two other ratings. As height has been shown to affect attractiveness, dominance, and strength perceptions, it was further hypothesized that these indicators of mate value would be equally affected in the same direction as the height appraisals, and that the height appraisals would mediate these effects. In addition, we examined how perceptions of large and small targets would change, depending on the height of the distractors (large, medium, & small). For the height ratings of short targets, the same predictions are made as for the medium target: if the targets are surrounded by large distractors, then height ratings should be smaller. In contrast, when the tallest targets are surrounded by the smallest distractors this should result in the rating as tallest. As the literature suggests that strength, i.e., muscularity, and dominance are linearly related to height, the same predictions are made for ratings of short and tall targets, and these ratings should be mediated by perceived height. For attractiveness, the predictions are less clear. As the male-not-too-tall norm (Stulp et al. 2013c) suggests that men who are too tall should be less desirable than slightly taller men, attractiveness ratings of tall targets surrounded by small distractors, therefore resulting in for example a 20% height difference, could be considered as less attractive compared with a smaller height difference, e.g., 10% difference when surrounded by medium distractors. For the short target, attractiveness is hypothesized to be higher when surround-

ed by small (same-height) distractors compared with taller distractors. However, it is unknown whether there is a cost in attractiveness when he is 20% shorter than the (large) distractors, compared with 10% shorter (medium distractors). Therefore, no further predictions are made for the perceived attractiveness of large and small targets when presented next to distractors.

Study 1

Material and Methods

Participants

In total, 107 female participants took part in the first study. As the focus of our study is on heterosexual mate preferences, one woman who did not report her sexual orientation, and two women who reported a bisexual sexual orientation were excluded from analyses. Of the remaining 104 participants, the age ranged from 18 to 44 years, with a mean age of 20.49 years (SD=3.14). Eighty-seven participants (84%) were Dutch, five Moroccan (5%), five Turkish (5%), and seven other (7%). Fifty-five (53%) were in a relationship, of which two were married, while the remaining 49 (47%) were single. The mean height was 169.58 cm (SD=6.88).

The subjects participated in a study called "Perception of Men" in the lab facilities of a large European university, and received either credits or a monetary reimbursement of €2 for their participation. Before participating, the subjects gave their informed consent. At the end of the study, there was a short debriefing describing the design and goals of the study.

2.1.2 Stimuli. For this experiment, the stimulus images depicted three men standing next to each other, where the person in the middle (i.e., target) was to be rated, and the two men flanking him on the left and right were the distractors. These images were computer generated using *DAZ Studio 4.6* (DAZ Studio 2013). In total, 15 male models were generated, of which nine were randomly selected to serve as targets and the remaining six as distractors. In each stimulus image, the distractors were always the same image copied, to reflect the stimulus composition of Bateson et al.'s (2014) study. All men depicted were presented in neutral underwear, i.e., a white tank top and a pair of boxer shorts. Since the body type of the models used to create the images were of the exact same stature and muscularity, the poses, skin tones, and color of the boxer shorts were varied slightly between all 15 models, to have them appear more dissimilar. The faces were obscured by black squares, to ensure focus of the ratings on the body. Depending on the condition, the size of the models (both targets and distractors) was small (S), medium (M), or large (L). Taking the medium size as the baseline, the small models were reduced to 90% of the size of the medium model, i.e., both in height and width, while the large models were enlarged to 110%, also in both height and width. The background of the images was white, with a thin black line near the bottom at which the models were positioned, to indicate that they were all standing at the same level and to make the height difference more salient. The stimulus images were 700 × 700 pixels large, and were presented on 23" LCD displays (1680 × 1050 resolution).

In total, 54 images were created, where each of the nine targets was paired

once with each of the six distractors. Of the six images per target, two were of small size, two medium, and two large. These 54 images were split into six blocks with nine images each, where each block included all nine different targets once, while three of them were small, three medium, and three large, with each target size being surrounded once by small, once by medium, and once by large distractors. Therefore, each block contained all nine conditions, where the size pair-

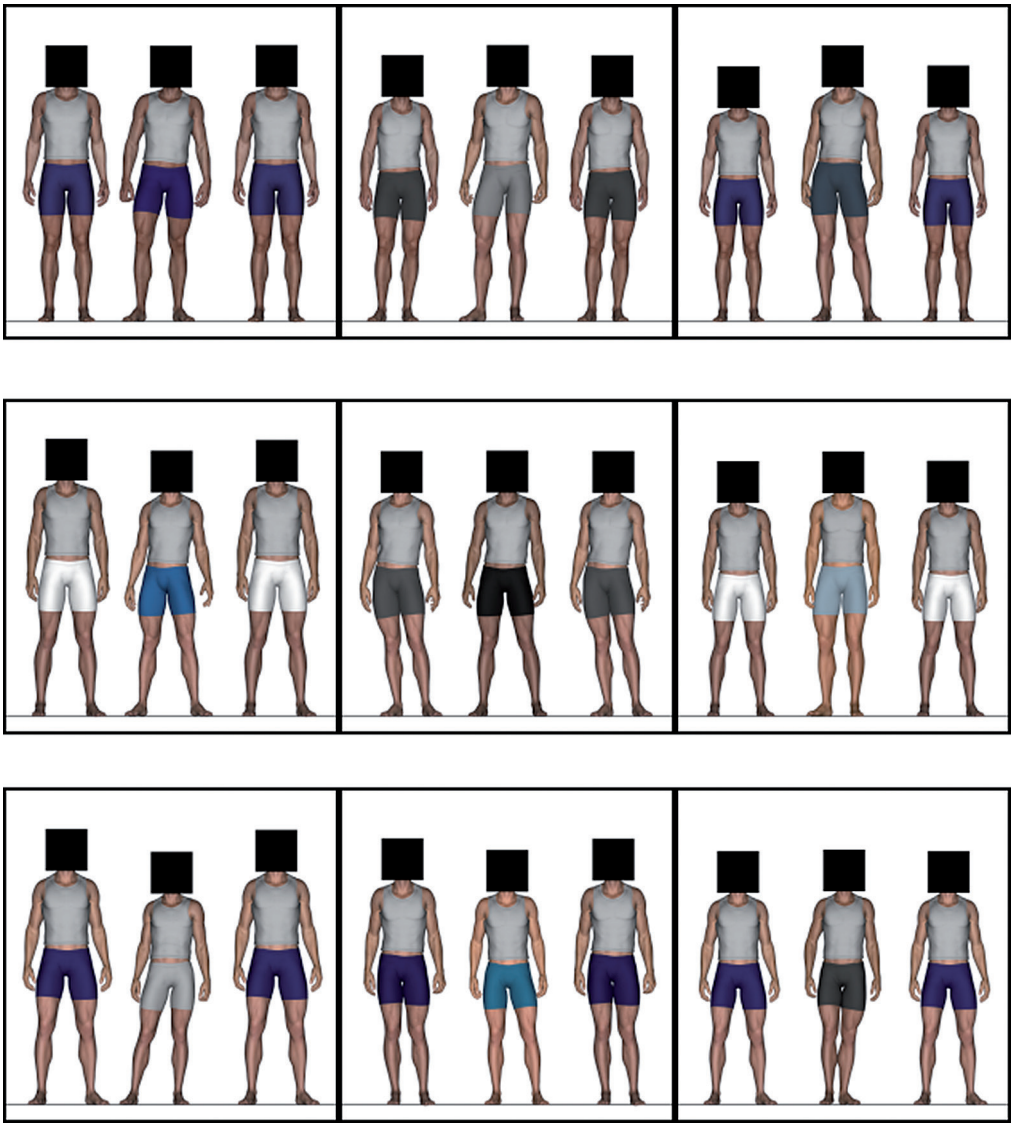

Fig. 1. Example of stimulus images used in Study 1. First row shows large targets, second row medium targets, and third row small targets. They are each surrounded by (from left to right) large, medium, and small distractors

ings of target and distractors were LL, LM, LS, ML, MM, MS, SL, SM, and SS (Fig. 1 for an example of the images of one block). Each participant was randomly assigned to one of the six blocks.

Procedure

After the informed consent, the participants were informed that they would see a series of images, and that each trial would be followed by a few questions about the target person in the middle, whom they should focus on. Each image was presented for three seconds, and then followed by questions about the attractiveness, dominance, muscularity, and height of the target. Attractiveness was measured on a 7-point Likert scale, ranging from 1='very unattractive' to 7='very attractive' (cf. Shepperd and Strathman 1989). Dominance was also measured on a 7-point Likert scale ranging from 1='not at all dominant' to 7='very dominant' (cf. Marsh et al. 2009). For muscularity, the participants had to choose which image resembled the target most on a 6-point array ranging from low to high muscularity (Fig. 2A). The viewing order of these three questions was randomized. Then, the participants had to estimate the size of the target using a 6-point array of men with increasing height (Fig. 2B), followed by an estimation of the height of the target in cm.

The order of the nine trials was randomized for each participant, to counterbalance any potential order effects. Following these trials, the subjects were asked a few questions about the height of their ideal and, if applicable, current partner, and finally answered some demographic questions, i.e., their age, height, nationality, relationship status, self-perceived attractiveness (7-point Likert scale from 1='very unattractive' to 7='very attractive'; cf. Vukovic et al. 2008) and body type ('athletic', 'lean/skinny', 'regular', or 'overweight'). Ethical approval for this study and the second study was obtained from the Ethics review board of the university where it was conducted.

Statistical analysis

As the hypotheses were slightly different for the different targets (small, medium, & large) the analyses were performed for each target size separately. The main effects of condition (small, medium, & large distractors) on the dependent variables height, attractiveness, dominance, and muscularity were analyzed with repeated measures multivariate analyses of variance (MANOVAs) using *IBM SPSS Statistics 19*. As the height rating on the 6-point array and the height rating in cm conceptually measured the same, only one of the two variables was included in the analyses (Mayers 2013). We selected the 6-point rating as it tended to explain slightly more variance. However, all analyses were also run with the height in cm measure instead. The results did not differ in a meaningful way, and are therefore not reported.

For pairwise comparisons, Bonferroni corrections were applied. The role of between-subject factors or covariates on the ratings was tested via separate repeated measures MANCOVAs and factorial MANOVAs. As the repeated measures mediation analyses with a categorical independent variable with three levels would have required elaborate calculations and recoding in SPSS, the mediations were instead performed using R version 3.1.1 (R Development Core Team 2008) and the *lmerTest* package

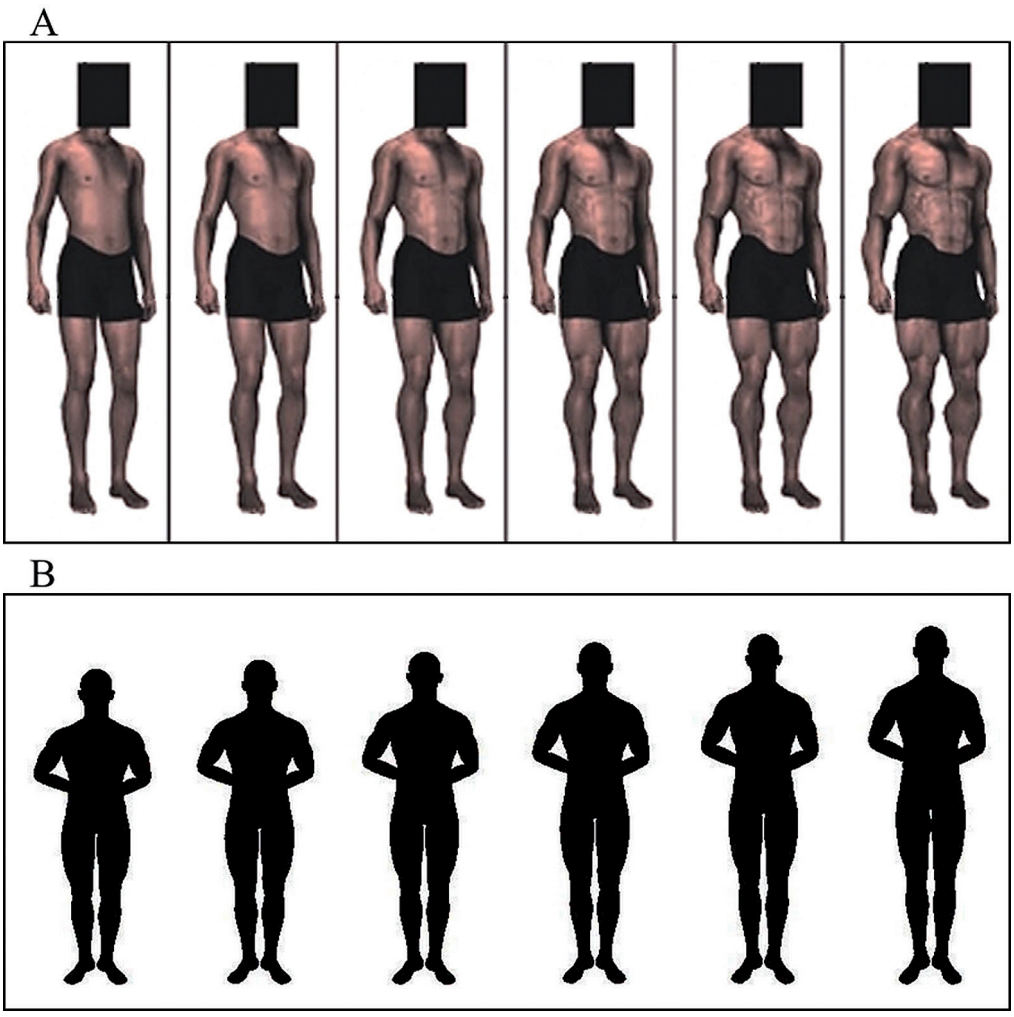

Fig. 2. Arrays used to assess target ratings of muscularity and height. Figure 2A depicts the 6-point array used to assess muscularity of targets, modified from Fessler et al. (2012). Figure 2B depicts the 6-point array used to assess the height of targets, modified from N. M. Blaker's unpublished work

(Kuznetsova and Brockhoff 2012). Sobel tests were calculated using an online calculation tool (Preacher and Leonardelli 2003).

Results

Medium target

For the medium target we hypothesized that the attractiveness, dominance, muscularity, and height appraisals would be highest when the distractors were of small size (condition MS), and the ap-

praisals would be lowest when the distractors were of large size (condition ML). When surrounded by same size distractors (condition MM), the appraisals should fall in between the two ratings of large and small distractors.

Using Pillai's trace, there was a significant overall effect of the height of the distractors on the ratings of attractiveness, dominance, muscularity, and height, $V=0.639$, $F(8, 408)=23.971$, $p<0.001$, $\eta_p^2=0.320$. Furthermore, separate univariate ANOVAs on the outcome variables revealed significant distractor height effects on all dependent variables: Attractiveness: $F(2, 206)=23.890$, $p<0.001$, $\eta^2=0.188$; Dominance: $F(2, 206)=6.015$, $p<0.001$, $\eta^2=0.055$; Muscularity: $F(2, 206)=10.437$, $p=0.006$, $\eta^2=0.092$; Height: $F(2, 206)=112.561$, $p<0.001$, $\eta^2=0.522$.

Pairwise comparisons revealed that for the height appraisals, all conditions were significantly different from each other (all $p<0.001$; see Table 1). The target was rated as significantly shorter when surrounded by tall or medium distractors compared with short distractors, and as significantly shorter when surrounded by tall distractors, compared with medium distractors. For attractiveness, dominance, and muscularity, the difference between the large and medium, and the large and small distractors were significantly different (all $p<0.032$). The medium target was rated as significantly less attractive, dominant, and muscular when surrounded by large distractors compared to either medium or small distractors. There was no significant difference between the medium and small distractors (see Fig. 3).

Covariates and between-subject factors

To investigate whether any between-subject factors or covariates had an effect on

Table 1. Study 1: Pairwise comparisons between conditions for Medium target (N=104)

Dependent Variable	Condition comparison	MD	SE	p	95% CI
Height	LM	–1.08	0.11	< 0.001	[–1.33, –0.82]
	LS	–1.68	0.12	< 0.001	[–1.98, –1.39]
	MS	–0.61	0.12	< 0.001	[–0.89, –0.33]
Attractiveness	LM	–0.97	0.14	< 0.001	[–1.31, –0.64]
	LS	–0.64	0.15	< 0.001	[–0.99, –0.28]
	MS	0.34	0.14	0.062	[–0.01, 0.69]
Dominance	LM	–0.39	0.15	0.032	[–0.75, –0.02]
	LS	–0.54	0.17	0.006	[–0.96, –0.12]
	MS	–0.15	0.16	1.000	[–0.54, 0.24]
Muscularity	LM	–0.34	0.11	0.010	[–0.61, –0.06]
	LS	–0.57	0.13	< 0.001	[–0.88, –0.25]
	MS	–0.23	0.13	0.245	[–0.55, 0.09]

Note. *p*-values adjusted with Bonferroni correction. MD=mean difference, SE=standard error, CI=confidence interval, LM=large vs. medium distractor, LS=large vs. small distractor, MS=medium vs. small distractor.

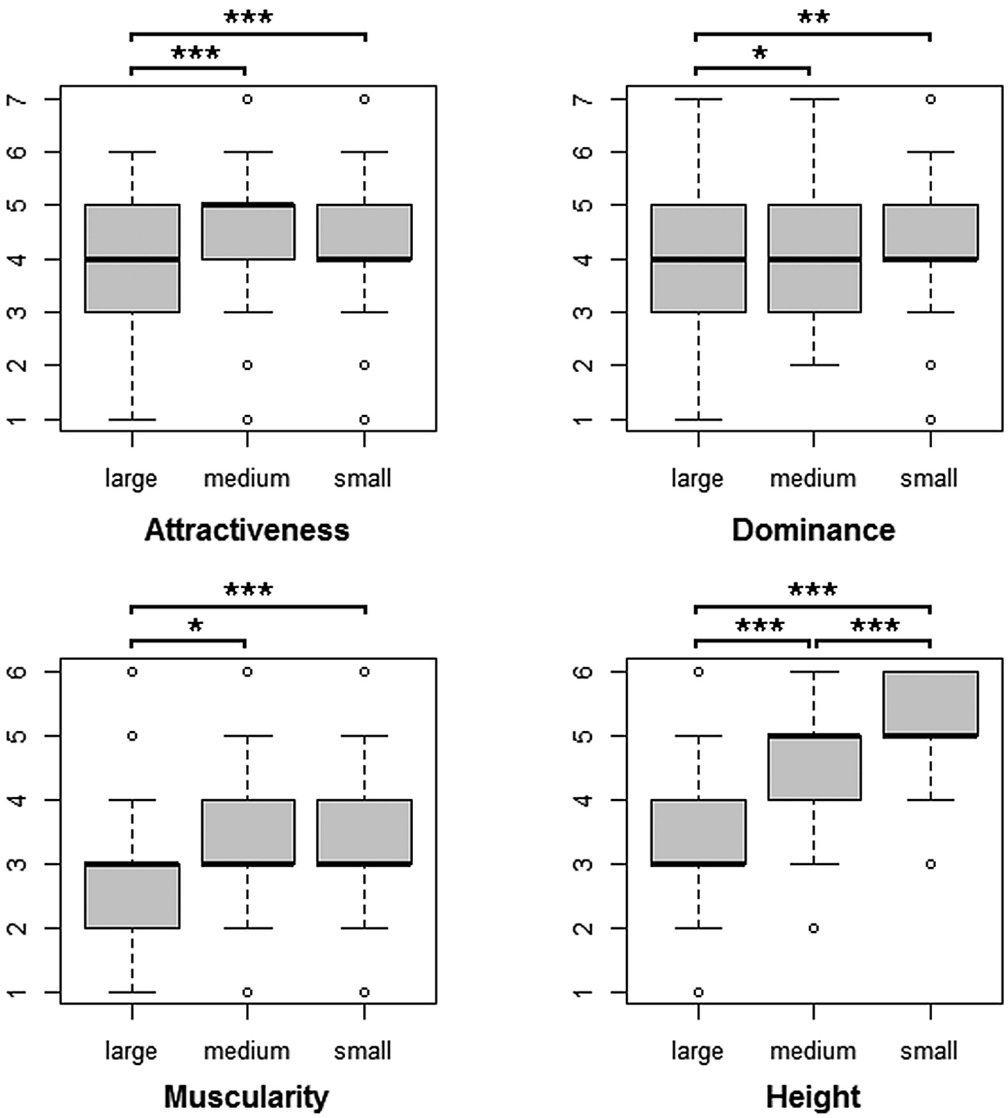

Fig. 3. Study 1: Difference in attractiveness, dominance, muscularity, and height ratings for Medium target. The different levels indicate large, medium, and small distractors. The thick line indicates the median, the box ranges from the first to third quartile, and the whiskers extend to +/– 1.5 interquartile ranges *$p<0.05$; **$p<0.01$; ***$p<0.001$ (values taken from pairwise comparisons in repeated measures MANOVAs, Bonferroni correction applied)

the ratings, separate analyses were performed with the participants' age, height, self-rated attractiveness, ideal partner height (in cm), body type, relationship status (single vs. in a relationship), and nationality (Dutch vs. non-Dutch) included in the model. For nationality, the main effect ($F(4, 99)=2.298$, $p=0.064$, $\eta^2=0.085$), and the interaction with condition ($F(8, 404)=1.936$, $p=0.053$,

η_p^2=0.037) were both near the 5% significance level. However, due to the repeated significance testing without α-correction, and the highly unequal group sizes for nationality (Dutch=87, Non-Dutch=17), we did not further investigate this pattern. None of the other factors and covariates had a significant main effect on the dependent variables (all F<2.04, all p>0.096), nor were any interactions with the condition significant (all F<1.60, all p>0.125).

Mediation

Finally, as we hypothesized that the difference in attractiveness, dominance, and muscularity ratings would be caused by the difference in perceived height, we tested whether these ratings were mediated by the height appraisals (see electronic supplementary material (ESM) for full mediation results of both Study 1 and Study 2).

For attractiveness, the effect of the difference between the large and medium distractors and the difference between the large and small distractors on attractiveness were significant. Furthermore, the effect of height on attractiveness, while keeping condition constant, was significant, in that higher appraisals of height resulted in higher appraisals of attractiveness. The Sobel test confirmed that for the difference between the large and medium distractors, the mediation was significantly different from zero, z_{test}=4.733, p<0.001. This is a partial mediation, because while the direct effect of condition on attractiveness (B=0.971, p<0.001; see ESM Table 1) was attenuated, it remained significant (B=0.554, p<0.001) when including the mediator. For the difference between the large and small distractors, the Sobel test also supported mediation, z_{test}=5.121, p<0.001. In this case there was a full mediation, as the direct effect of condition on attractiveness (B=0.635, p<0.001) was no longer significant when the mediator was added (B=–0.017, p=0.923).

With regards to dominance, the effect of the difference between the large and medium distractors and the difference between the large and small distractors on dominance was significant. Furthermore, the effect of height on dominance, while keeping condition constant, was significant, in that higher appraisals of height resulted in higher appraisals of dominance. There was support for a mediated effect for the difference between the large and medium distractors, z_{test}=3.876, p<0.001. This was a full mediation, as the direct effect of condition on dominance (B=0.385, p=0.017) was no longer significant when including the mediator height in the model (B=0.020, p=0.909). For the difference between the large and small distractors, a similar full mediation was found (z_{test}=4.080, p<0.001; direct effect of condition on dominance: B=0.536, p<0.001; effect when perceived height was included as mediator in the model: B=–0.031, p=0.881).

For muscularity, the effect of the difference between the large and medium distractors, and the difference between the large and small distractors on muscularity was significant. Furthermore, the effect of height on muscularity, while keeping condition constant, was significant, in that higher appraisals of height resulted in higher appraisals of muscularity. As with dominance, there was evidence for two full mediations of the effect of condition on dominance via perceived height (respectively: large vs. medium distractors: z_{test}=3.850, p<0.001,

direct effect of condition on muscularity: B=0.337, p=0.007, after inclusion of mediator: B=0.058, p=0.672; large vs. small distractors: z_{test}=4.051, p<0.001, direct effect of condition on muscularity: B=0.567, p<0.001, after inclusion of mediator: B=0.132, p=0.405).

Large target

Given that the distractors were large, medium, and small, for the large target, the target was either of same height as the distractors (condition LL), 10% taller (condition LM) or 20% taller (condition LS). As described above, we hypothesized that the dominance, muscularity, and height appraisals would be highest when the distractors were of small size (LS), and lowest when the distractors were of the same size (LL). When surrounded by medium distractors (LM), the appraisals should fall in between the two ratings. For attractiveness, no hypotheses were formulated.

Using Pillai's trace, there was a significant overall effect of the height of the distractors on the ratings of attractiveness, dominance, muscularity, and height, V=0.537, F(8, 408)=18.725, p<0.001, η_p^2=0.269. Furthermore, separate univariate ANOVAs on the outcome variables revealed significant distractor height effects on all dependent variables: Attractiveness: F(2, 206)=10.318, p<0.001, η^2=0.091; Dominance: F(2, 206)=7.016, p=0.001, η^2=0.064; Muscularity: F(2, 206)=6.186, p=0.002, η^2=0.057; Height: F(2, 206)=80.897, p<0.001, η^2=0.440.

Pairwise comparisons revealed that for height appraisals, all conditions were significantly different from each other (all p<0.003; see Table 2). The target was rated as significantly shorter when surrounded by tall or medium distractors compared with small distractors, and as significantly shorter when surrounded by tall distractors, compared with medium distractors. For attractiveness, the large target was rated as significantly more

Table 2. Study 1: Pairwise comparisons between conditions for Large target (N=104)

Dependent Variable	Condition comparison	MD	SE	p	95% CI
Height	LM	–0.84	0.10	< 0.001	[–1.07, –0.60]
	LS	–1.15	0.10	< 0.001	[–1.39, –0.92]
	MS	–0.32	0.09	0.002	[–0.53, –0.10]
Attractiveness	LM	–0.55	0.13	< 0.001	[–0.88, –0.22]
	LS	–0.03	0.14	1.000	[–0.38, 0.32]
	MS	0.52	0.13	< 0.001	[0.21, 0.83]
Dominance	LM	–0.50	0.13	< 0.001	[–0.81, –0.19]
	LS	–0.34	0.14	0.060	[–0.68, 0.01]
	MS	0.16	0.14	0.718	[–0.17, 0.50]
Muscularity	LM	–0.35	0.10	0.003	[–0.60, –0.10]
	LS	–0.34	0.12	0.021	[–0.63, –0.04]
	MS	0.01	0.11	1.000	[–0.26, 0.28]

Note. p-values adjusted with Bonferroni correction. MD=mean difference, SE=standard error, CI=confidence interval, LM=large vs. medium distractor, LS=large vs. small distractor, MS=medium vs. small distractor.

attractive when surrounded by medium distractors, compared with either large or small distractors. For dominance, only the difference between the large and medium distractors was significant, with the large distractors yielding significantly lower dominance scores than when surrounded by the medium distractors. Finally, for muscularity, the targets were rated as significantly more muscular when surrounded by either small or me-

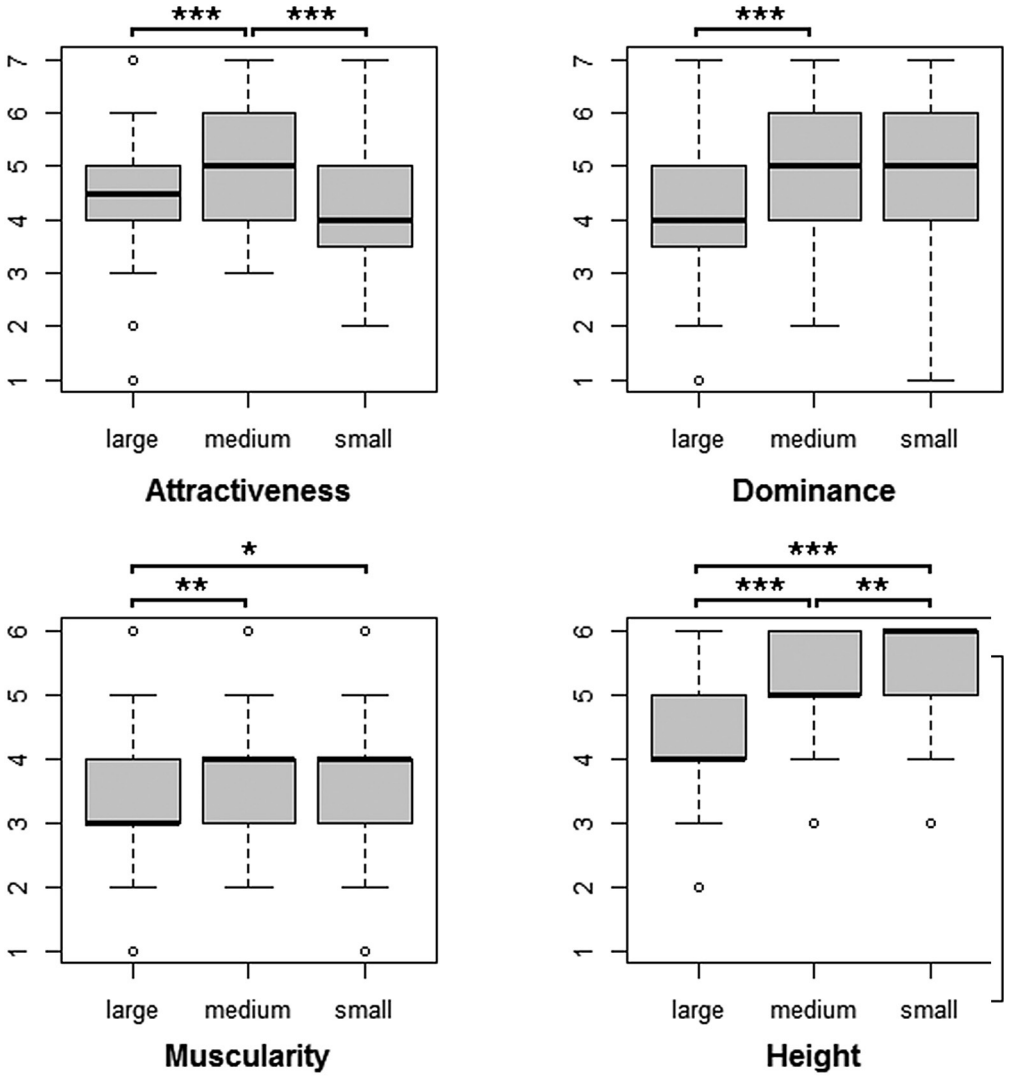

Fig. 4. Study 1: Difference in attractiveness, dominance, muscularity, and height ratings for Large target. The different levels indicate large, medium, and small distractors. The thick line indicates the median, the box ranges from the first to third quartile, and the whiskers extend to +/– 1.5 interquartile ranges *$p<0.05$; **$p<0.01$; ***$p<0.001$ (values taken from pairwise comparisons in repeated measures MANOVAs, Bonferroni correction applied)

dium distractors, compared to large distractors (Fig. 4).

Covariates and between-subject factors

None of the factors and covariates had a significant main effect on the dependent variables (all $F<2.21$, all $p>0.074$), nor were any interactions with the condition significant (all $F<1.30$, all $p>0.242$).

Mediation

Concerning attractiveness, although the effects of the difference between the medium and large, and the medium and small distractors on the potential mediator height were significant, the effect of height on the attractiveness ratings, while keeping condition constant, was not. As the significance level almost reached the 5%-level ($p=0.055$), the Sobel tests were performed nevertheless. The difference in attractiveness ratings between the medium and large, and the medium and small conditions were not significantly mediated by the difference in height appraisals, but there was a statistical trend (difference ML: $z_{test}=-1.889$, $p=0.059$; difference MS: $z_{test}=1.678$, $p=0.093$; for more information, see ESM Table 2).

The significant difference in dominance ratings between the large and medium distractors was partially mediated by the difference in height appraisals, as the direct effect was attenuated but still significant ($p=0.035$) when including the mediator in the model ($z_{test}=2.189$, $p=0.029$).

The significant pairwise differences of muscularity (difference LM & difference LS) were fully mediated by height (difference LM: $z_{test}=3.194$, $p=0.001$; difference LS: $z_{test}=3.295$, $p<0.001$), as the direct effects were attenuated and no longer significant (both $p>0.281$) when including the mediator in the model.

Small target

For the small target, the target was either of the same height as the distractors (condition SS), 10% shorter (condition SM), or 20% shorter (condition SL). We hypothesized that the height, dominance, and muscularity appraisals would be highest when the distractors were of the same size (SS), and lowest when the distractors were tallest (SL), and the ratings falling between these two when surrounded by medium distractors (SM). For attractiveness, it was only hypothesized that the appraisal would be highest when surrounded by small distractors, but no other predictions were made.

Using Pillai's trace, there was a significant overall effect of the height of the distractors on the ratings of attractiveness, dominance, muscularity, and height, $V=0.594$, $F(8, 408)=21.526$, $p<0.001$, $\eta_p^2=0.297$. Furthermore, separate univariate ANOVAs on the outcome variables revealed significant distractor height effects on all dependent variables. As Mauchly's test indicated that the assumption of sphericity was violated for the main effects of dominance, $\chi^2(2)=6.380$, $p=0.041$, and height, $\chi^2(2)=10.790$, $p=0.005$, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.94$ for the main effect of dominance, and $\varepsilon=0.91$ for the main effect of height): Attractiveness: $F(2, 206)=18.204$, $p<0.001$, $\eta^2=0.150$; Dominance: $F(1.886, 194.224)=7.884$, $p=0.001$, $\eta^2=0.071$; Muscularity: $F(2, 206)=5.183$, $p=0.006$, $\eta^2=0.048$; Height: $F(1.818, 187.208)=129.526$, $p<0.001$, $\eta^2=0.557$.

Pairwise comparisons revealed that for the height appraisals, all conditions were significantly different from each other (all $p<0.001$; see Table 3). The target was rated as significantly shorter when surrounded by tall or medium distractors compared with small distractors, and as significantly shorter when surrounded by tall distractors, compared with medium distractors.

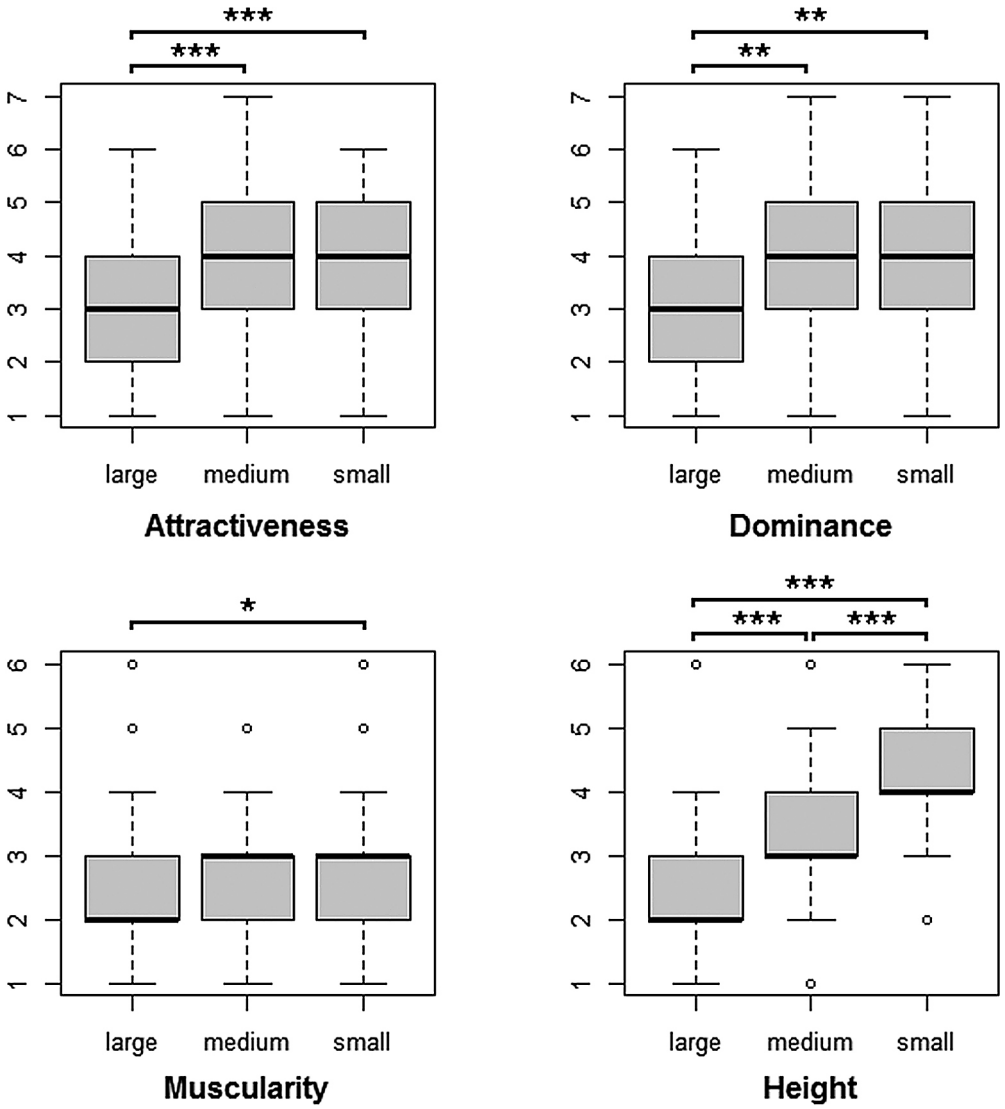

Fig. 5. Study 1: Difference in attractiveness, dominance, muscularity, and height ratings for Small target. The different levels indicate large, medium, and small distractors. The thick line indicates the median, the box ranges from the first to third quartile, and the whiskers extend to +/– 1.5 interquartile ranges *$p<0.05$; **$p<0.01$; ***$p<0.001$ (values taken from pairwise comparisons in repeated measures MANOVAs, Bonferroni correction applied)

Table 3. Study 1: Pairwise comparisons between conditions for Small target (N=104)

Dependent Variable	Condition comparison	MD	SE	p	95% CI
Height	LM	–0.83	0.12	< 0.001	[–1.11, –0.54]
	LS	–1.65	0.09	< 0.001	[–1.88, –1.43]
	MS	–0.83	0.10	< 0.001	[–1.06, –0.60]
Attractiveness	LM	–0.63	0.15	< 0.001	[–0.99, –0.26]
	LS	–0.90	0.15	< 0.001	[–1.26, –0.55]
	MS	–0.28	0.16	0.278	[–0.68, 0.12]
Dominance	LM	–0.47	0.14	0.004	[–0.82, –0.13]
	LS	–0.61	0.18	0.002	[–1.03, –0.18]
	MS	–0.14	0.16	1.000	[–0.53, 0.26]
Muscularity	LM	–0.18	0.11	0.268	[–0.44, –0.08]
	LS	–0.38	0.13	0.010	[–0.68, –0.07]
	MS	–0.19	0.12	0.315	[–0.48, 0.09]

Note. *p*-values adjusted with Bonferroni correction. MD=mean difference, SE=standard error, CI=confidence interval, LM=large vs. medium distractor, LS=large vs. small distractor, MS=medium vs. small distractor.

Furthermore, small targets were rated as significantly more attractive and dominant when surrounded by small or medium distractors, compared with large distractors, and as significantly more muscular when surrounded by small distractors, compared with large distractors (Fig. 5). None of the other differences were significant.

Covariates and between-subject factors

Again, none of the factors and covariates had a significant main effect on the dependent variables (all $F<1.63$, all $p>0.143$), nor were any interactions with the condition significant (all $F<1.80$, all $p>0.077$).

Mediation

All of the four pairwise differences of attractiveness and dominance that were significant (difference LM & difference LS) were fully mediated by height (all $z_{test}>4.033$, all $p<0.001$; see ESM Table 3), as all of the direct effects were attenuated and no longer significant (all $p>0.172$). The significant difference between the large and small distractors on muscularity was partially mediated ($z_{test}=6.977$, $p<0.001$), as the direct effect on muscularity was attenuated but still significant ($p=0.010$). This means that all significant differences between the conditions in attractiveness and dominance were fully due to perceived height, while the significant difference between conditions in muscularity ratings was only partially due to the difference in height appraisals.

Discussion

Across all target sizes, the height ratings between all conditions were significantly different in the direction predicted, in that small distractors resulted in the largest height ratings of the targets, large distractors resulted in the lowest height ratings, and medium distractors result-

ed in ratings in between. Therefore, the height contrast illusion was successful in this study, as all same-sized targets were rated to be of significantly different heights when surrounded by differently sized distractors.

Furthermore, in most cases, these differences in height perception had an effect on the mate value perceptions of the targets (i.e., attractiveness, dominance, and muscularity). For the medium target, all but one of the differences in mate value perceptions were fully mediated by the difference in height appraisals between conditions, with the remaining difference (attractiveness in the LM condition) being partially mediated. When the targets were surrounded by larger distractors, they were significantly less attractive, dominant, and muscular than when surrounded by same height or shorter distractors. There was no difference between same height and shorter distractors, implying that as long as the target is not shorter than others, he is not appraised differently in regard to mate value.

For the large target, the results varied more. The target was rated as significantly more attractive when surrounded by slightly shorter distractors (condition LM) than when either surrounded by same height, or much shorter (condition LS) distractors. This could imply that the male-not-too-tall norm did in fact come into play, in that the target became more attractive when he appeared taller, compared to the same height, but attractiveness declined again when the target became too tall (i.e., condition LS). However, since the height ratings could only be made relative to the distractors, in the 20% height difference condition, theoretically it was equally likely that the distractors were much shorter than average, instead of the target being much taller. Therefore, whether the male-not-too-tall norm accounts for this effect is debatable. Furthermore, the dominance rating was only significantly different for the comparison between the same height and slightly shorter distractors, but not between the same height and much shorter conditions. It seems that dominance did not vary as much between the tall targets, perhaps implying that size illusions do not have a large effect if the target is already being perceived as tall, perhaps due to a ceiling effect. The findings on muscularity ratings were in line with our predictions: the target was perceived as more muscular when surrounded by shorter distractors (LM and LS), compared with same height distractors. Both these effects were fully mediated by the height appraisals. Therefore, to change the perceived muscularity, the large target had to be taller than the distractors and not the same height, but it did not matter how much taller he ended up being.

For the small target, the results were also less clear than for the medium target. The perceived attractiveness did not change when surrounded by either same-sized or slightly taller distractors. However, being surrounded by much taller distractors did have an effect, decreasing attractiveness both compared to the medium (slightly taller distractors) and small (same height) condition. The dominance ratings showed the same pattern, with only the large distractors resulting in lower dominance, compared to the other two conditions. This implies that for small targets, being slightly smaller than others (10%) does not have a measurable effect on judgments of attractiveness and dominance, but if this difference becomes larger (20%), this does affect the ratings. For muscularity,

only the large height difference (20%) resulted in a lower score compared with the same height, implying that here again, being slightly shorter than the distractors did not have a measurable effect. However, these ratings were generally rather low (M_{SL}=2.53, SD_{SL}=1.09; M_{SM}=2.71, SD_{SM}=0.91; M_{SS}=2.90, SD_{SS}=0.91), implying that when the target is small, there is a potential floor effect.

However, since the models in this study were presented in front of a white background, and were wearing only underwear, our study has quite low ecological validity. With no background to compare the models to, the height ratings could only be made in relation to the distractors. While this is of course the original intent of the contrast illusion, in that height perceptions change because of the relative difference to the distractors, it is possible that when individuals have a better reference for absolute size the size illusion does not work. Therefore, in the second study, we investigated whether the size illusion still occurs when giving the participants a constant visual anchor to compare the heights to in a more absolute sense, and to give them an indication of how the targets' height might generally compare to the participants' own height.

Additionally, we decided to only investigate the height illusion of the medium target further. Therefore, the second study only focused on contrast illusions of medium targets surrounded by either shorter, same height, or taller distractors, as this reflects the same design most literature on size illusions in mate choice so far has focused on (e.g., Bateson et al. 2014; Callander et al. 2012), and the predictions as well as conclusions can be based on and related to.

Study 2

Materials and Methods

Participants

In total, 84 female participants took part in the second study, four of which were excluded from analyses based on sexual orientation. Of the remaining 80 participants, the age ranged from 18 to 27 years, with a mean age of 20.99 years (SD=2.28). Sixty-four participants (80%) were Dutch, three Greek (4%), and 13 other (16%). Thirty-six (45%) were in a relationship, of which one was married, while the remaining 44 (55%) were single. The mean height was 168.28 cm (SD=7.32). Individuals who had participated in the previous study could not take part in this study.

The subjects participated in the study called "Perception of Men Part II" in the lab facilities of a large European university, and received either credits or a monetary reimbursement of €2 for their participation. Before participating, the subjects gave their informed consent. At the end of the study, there was a short debriefing explaining the design and goals of the study.

Stimuli

The basic setup of the stimulus images for this study was the same as in the first study, depicting three men standing next to each other, where the person in the middle (i.e., target) was to be rated, and the two men flanking him on the left and right were the distractors. These images were again computer generated using *DAZ Studio 4.6 (*DAZ Studio 2013*)*.

Thirteen of the models used in the first study were chosen, with six randomly selected to serve as targets, and seven randomly chosen as distractors. This time, the distractors to the left and right of the target, although still of the same height, were different male models in each image, to improve the realism further. Furthermore, the models depicted wore full clothing instead of only underwear, i.e., a pair of blue jeans, a white t-shirt, and black shoes. The jeans varied in color (light, medium, and dark), with the three models in each image wearing a different color. The order of this was randomized for each image, to counterbalance any potential effects of jeans color. The faces were again blocked out by black squares, to increase focus on the body. Most importantly, backgrounds were added, to further increase the realism of the images, and to give the participants a reference point to judge the individuals' heights. There were three backgrounds: a bus stop on a city street, a back alley with graffiti on the wall, and a partially open garage door of a house with a car parked inside. These backgrounds were chosen to depict different visual scenarios so that potential differences in ratings were not due to a specific background setting the models were presented in. The backgrounds were counterbalanced across all images, so that every target and combination with differently sized distractors was presented with all possible backgrounds. The stimulus images were 700 × 800 pixels large, and were presented on 23" LCD displays (1680 × 1050 resolution).

The size of the target was kept constant to medium height in every image, with the distractors being either small (90% size), medium (same size), or large (110% size). Within the *DAZ Studio* program (DAZ Studio 2013), these heights were set to 171 cm (small), 180 cm (medium), and 189 cm (large), and scaled accordingly in relation to the background. As the participants consisted of mainly Dutch women, 180 cm was chosen as the medium height, as this approximately reflects the average male height in the Dutch population (183.8 cm; Schönbeck et al. 2013).

In total, 36 images were created, where each of the six targets was paired with a combination of the seven distractors. These 36 images were split into six blocks with six images each, where each block included all six different targets once, while two of them were surrounded by small, two by medium, and two by large distractors. Therefore, each block contained all three conditions twice, where the size pairings of target and distractors were ML, MM, and MS (Fig. 6 for an example of the images of one block). Each participant was randomly presented one of the six blocks.

Procedure

The procedure was the same as in the first study. After the informed consent, the participants saw the six images for three seconds, each followed by questions about the targets' attractiveness, dominance, muscularity, and height. The order of the six trials was randomized for each participant, to counterbalance any potential order effects. Following these trials, the subjects were asked a few questions about the height of their ideal partner and, if applicable, their current partner, and finally answered the same demographic questions as in Study 1.

*Statistical analysis***.** The same statistical tests as in Study 1 were used. As every participant saw each condition twice, the

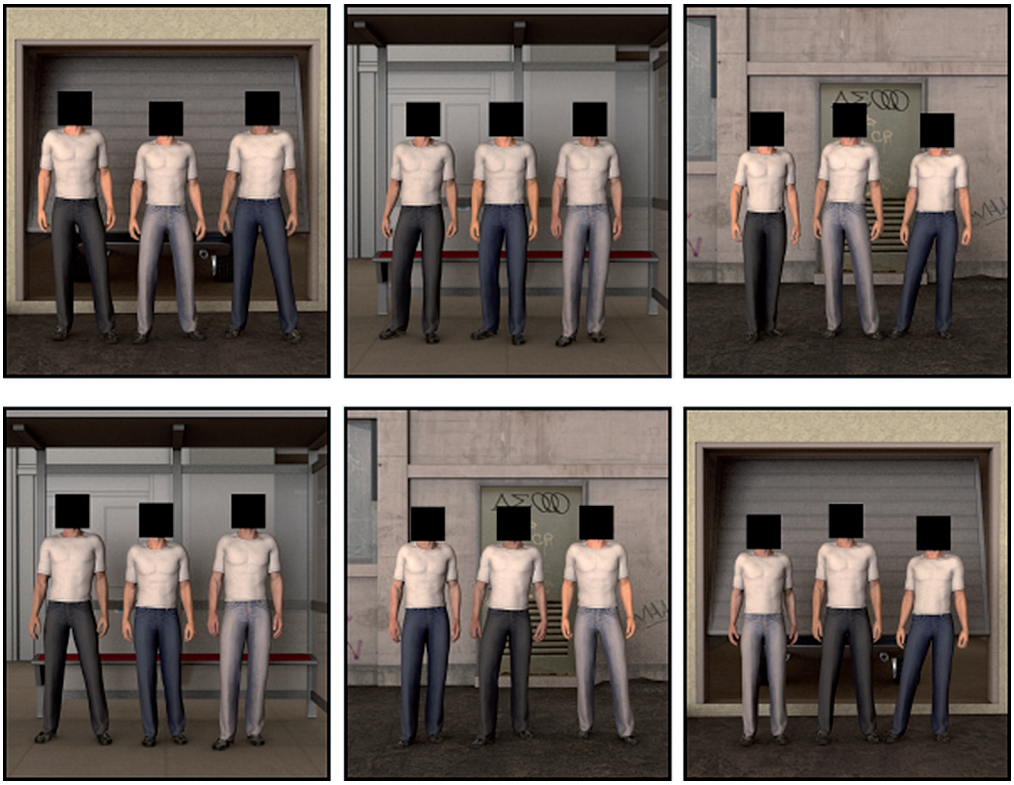

Fig. 6. Example of stimulus images used in Study 2. In the left column, the targets are surrounded by large distractors, in the middle column by medium (same size) distractors, and in the right column by small distractors

two ratings per condition were combined into a single score, by taking the average of the two values. We again selected the 6-point rating of height as it tended to explain slightly more variance than the height rating in cm. However, all analyses were also run with the height in cm measure instead. The results did not differ in a meaningful way, and are therefore not reported.

Results

It was again hypothesized that the attractiveness, dominance, muscularity, and height appraisals would be highest when the distractors were of small size (condition MS), and the appraisals would be lowest when the distractors were of large size (condition ML). When surrounded by same size distractors (condition MM), the appraisals should fall in between the two ratings of large and small distractors.

A repeated measures MANOVA revealed a significant overall effect of condition on the four appraisals. Using Pillai's trace, there was a significant effect of the height of the distractors on the ratings of attractiveness, dominance, muscularity, and height, $V=0.889$, $F(8, 312)=31.220$, $p<0.001$, $\eta_p^2=0.445$. Furthermore, separate univariate ANOVAs on the outcome variables revealed significant distractor height effects on

Table 4. Study 2: Pairwise comparisons between conditions (N=80)

Dependent Variable	Condition comparison	MD	SE	p	95% CI
Height	LM	–1.26	0.08	< 0.001	[–1.46, –1.07]
	LS	–2.10	0.11	< 0.001	[–2.37, –1.83]
	MS	–0.84	0.07	< 0.001	[–1.01, –0.66]
Attractiveness	LM	–0.91	0.11	< 0.001	[–1.17, –0.66]
	LS	–0.98	0.13	< 0.001	[–1.29, –0.67]
	MS	–0.07	0.12	1.000	[–0.39, 0.23]
Dominance	LM	–0.64	0.12	< 0.001	[–0.93, –0.34]
	LS	–1.21	0.16	< 0.001	[–1.59, –0.83]
	MS	–0.58	0.12	< 0.001	[–0.87, –0.28]
Muscularity	LM	–0.49	0.10	< 0.001	[–0.73, –0.25]
	LS	–0.88	0.12	< 0.001	[–1.16, –0.60]
	MS	–0.39	0.09	< 0.001	[–0.62, –0.17]

Note. *p*-values adjusted with Bonferroni correction. MD=mean difference, SE=standard error, CI=confidence interval, LM=large vs. medium distractor, LS=large vs. small distractor, MS=medium vs. small distractor.

all dependent variables. Mauchly's test indicated that the assumption of sphericity was violated for the main effects of dominance, $\chi^2(2)=11.229$, $p=0.004$, muscularity, $\chi^2(2)=6.970$, $p=0.031$, and height, $\chi^2(2)=29.496$, $p<0.001$. Therefore, the degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon=0.88$ for the main effect of dominance, $\varepsilon=0.92$ for the main effect of muscularity, and $\varepsilon=0.76$ for the main effect of height): Attractiveness: $F(2, 158)=42.615$, $p<0.001$, $\eta^2=0.350$; Dominance: $F(1.764, 139.320)=41.280$, $p<0.001$, $\eta^2=0.343$; Muscularity: $F(1.842, 145.557)=37.331$, $p<0.001$, $\eta^2=0.321$; Height: $F(1.521, 120.163)=278.662$, $p<0.001$, $\eta^2=0.779$.

Pairwise comparisons revealed that for height, dominance, and muscularity appraisals, all conditions were significantly different from each other (all $p<0.001$; see Table 4). The target was rated as significantly shorter, less dominant, and less muscular when surrounded by tall or medium distractors compared with short distractors, and as significantly shorter, less dominant, and less muscular when surrounded by tall distractors, compared with medium distractors. For attractiveness, the difference between the large and medium, and the large and small distractors were significantly different (both $p<0.001$). Hence, the target was rated as significantly less attractive when surrounded by larger distractors, compared to either medium or small distractors. However, there was no significant difference between the medium and small distractors (Table 4 and Fig. 7).

Covariates and between-subject factors

The effect of the between-subject factor relationship status was near the 5% significance level, $F(4, 75)=2.447$, $p=0.054$, $\eta^2=0.115$. As the group sizes were fairly equal (single=44, in a relationship=36), this effect was explored further. A univariate ANOVA revealed a significant effect

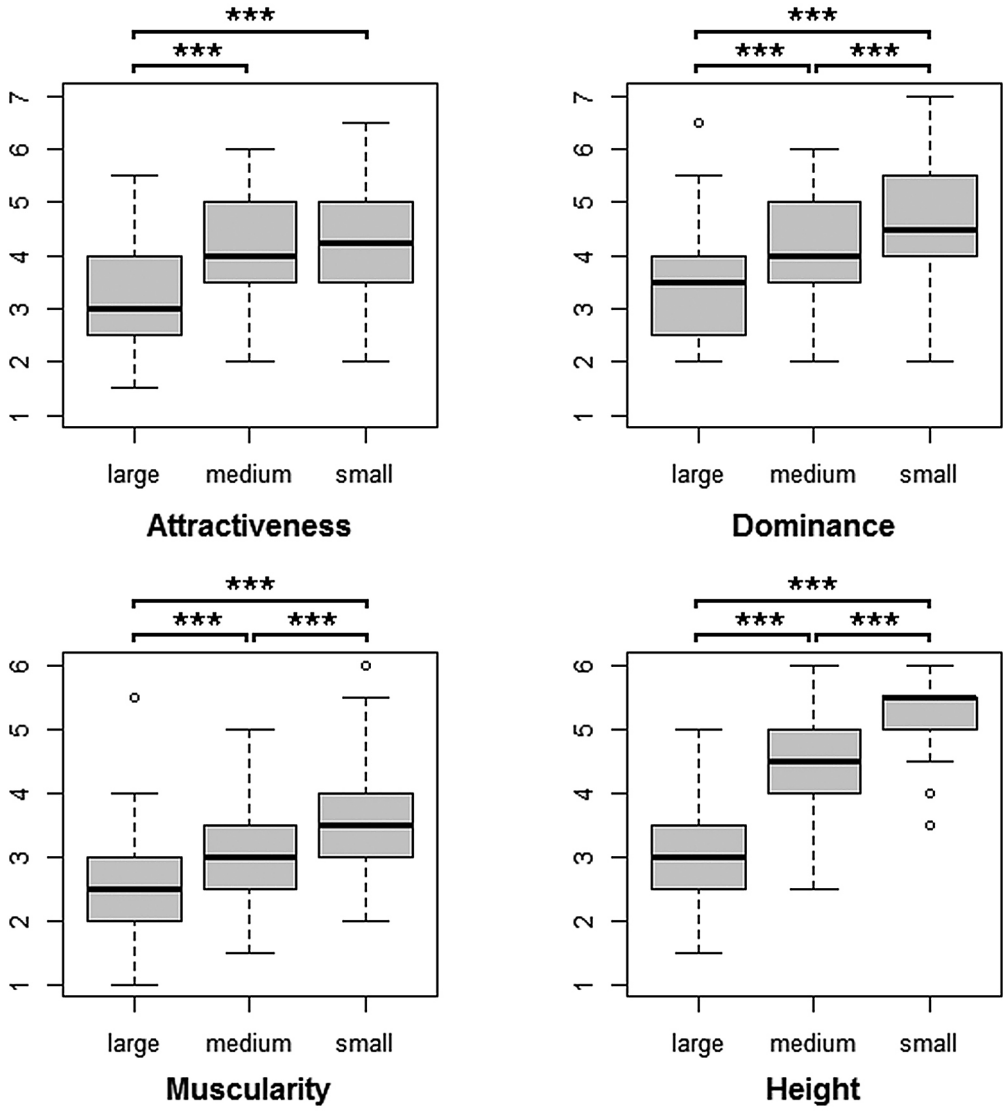

Fig. 7. Study 2: Difference in attractiveness, dominance, muscularity, and height ratings. The different levels indicate large, medium, and small distractors. The thick line indicates the median, the box ranges from the first to third quartile, and the whiskers extend to +/– 1.5 interquartile ranges
*$p<0.05$; **$p<0.01$; ***$p<0.001$ (values taken from pairwise comparisons in repeated measures MANOVAs, Bonferroni correction applied)

of the factor on height, $F(1, 78)=4.271$, $p=0.042$, $\eta^2=0.052$, in that single participants rated the targets as significantly taller (M=4.35, SD=0.56) than participants in a relationship (M=4.09, SD=0.58). There was, however, no significant interaction effect between condition and relationship status, $p=0.729$. None of the other between-subject factors and covariates had a significant main

effect on the dependent variables (all $F<2.04$, all $p>0.098$), nor were any interactions with condition significant (all $F<1.17$, all $p>0.260$).

3.2.2 Mediation. For attractiveness, the significant difference between the large and small distractors was fully, and the difference between large and medium partially mediated by the height appraisals (see ESM Table 4). For dominance, all three significant pairwise differences were partially mediated by the height appraisals. Finally, for muscularity, all three pairwise differences were fully mediated by height. Therefore, of all eight significant pairwise differences in attractiveness, dominance, and muscularity ratings, all were, at least partially, due to the difference in height appraisals.

Discussion

In the second study, nearly all of our hypotheses were fully supported. Although the targets were of the exact same (medium) height in every image, they were rated as significantly taller when surrounded by small distractors compared with medium and large distractors, and as significantly shorter when surrounded by large distractors, compared with medium distractors.

This result also had an effect on the ratings of attractiveness, dominance, and muscularity. Except for the difference in attractiveness between the medium and small distractors, all pairwise comparisons between conditions on the three variables were significant (all $p<0.001$, Bonferroni corrected). Therefore, the targets were rated as significantly less attractive, dominant, and muscular when surrounded by large distractors, compared with medium and small distractors, and as significantly more dominant and muscular when surrounded by small distractors, compared with medium distractors. All of these differences were at least partially mediated by the height appraisals, implying that it is likely because the targets were seen as taller or shorter, their attractiveness, dominance, and muscularity changed accordingly as well. Finally, height ratings differed significantly between single participants and those in a relationship, with the former viewing the targets as significantly larger than the latter. However, as there was no interaction with the condition, the observed height contrast illusion was unaffected by this difference.

General Discussion

Across two studies we found that when putting taller distractors next to a target, the contrast in size creates a height illusion that makes the target appear shorter than when surrounded by distractors of the same height. Similarly, when showing shorter distractors next to the target, this contrast creates the illusion that the target is taller than when standing next to distractors of the same height. Additionally, the first study showed that this contrast illusion even distorts height perceptions between smaller and larger height differences. For the large target, when the distractors were 10% smaller than the target, the target was still perceived as shorter than when the distractors were 20% smaller. This also worked in the opposite direction, in that when the small target was surrounded by 10% larger distractors, the target was still rated as taller than when surrounded by 20% larger distractors. Therefore, not only does it make a difference if the distractors are of different heights than the target, even within different degrees of

differences in height the perceptions are distorted accordingly.

To exclude the possibility that the visual illusion only works in the "sterile" environment of the first study, where the models were presented in front of a white background, in the second study natural backgrounds were included, and the images were made more realistic overall, by having the models wear full clothing and not having the same exact distractor to the left and right of the target. As the results were still significant, the visual illusion therefore still holds even if there are visual anchors present which could theoretically reveal to the participant that the height of the target is indeed the same in every image.

The second important finding is the effect this height illusion has on the perceived mate value of the target. To assess mate value, the perceived attractiveness, dominance, and muscularity of the target were assessed, where an increase in these ratings is assumed to increase mate value. Here, the results were dependent on the size of the target. For the medium target, the mate value was significantly higher in all pairwise comparisons when the distractors were smaller than the target, compared with the distractors being taller, and these differences were all mediated by the height perceptions. This is in line with the previous research on mate choice in animals, where the contrast illusions successfully affected mate value (Callander et al. 2012; Gasparini et al. 2013). However, these results were not found in a recent study of Bateson et al. (2014), the only other study so far that tested size illusions in human mate choice. An important difference between the findings of this research and those of Bateson et al. (2014) is that in their study, female attractiveness in relation to body size (i.e., BMI) was measured, whereas here, male attractiveness in relation to height was assessed. It is also important to note that Bateson et al. (2014) used a forced choice paradigm, whereas in our study, we did not employ this paradigm, as for assessments of height in a forced choice paradigm it would immediately be obvious which target is the tallest.

Furthermore, in both Study 1 and 2, surrounding the medium target with larger distractors always resulted in a significantly lower mate value than being surrounded by same height distractors, while the difference between smaller and same-size distractors was only significant in two out of six direct comparisons. It can therefore be argued that as soon as the target appears shorter than the others, this affects the mate value negatively, and the target will consistently be perceived as short. However, whether the target is the same height or slightly taller than the others is not as important as assessing shortness, and as a consequence this seems to have less of an impact on mate value. These results appear to be largely in line with predictions derived from error management theory (Haselton and Buss 2000; Haselton et al. 2005). All else being equal, it would be more important to scan for 'shortness' rather than for 'tallness'.

For the large and small targets, the results were less conclusive. The large target was perceived as most attractive when surrounded by slightly shorter distractors, while being surrounded by same height or much shorter distractors did not yield a difference. As discussed above, this might indicate the male-not-too-tall norm (Stulp et al. 2013c) coming into effect, in that women do not prefer a partner who is too tall compared to them. However, this would assume that

the participants perceived the target as overly tall, and not the distractors as overly short. While this is a viable explanation, more research is needed to investigate this. For the small target, there were no differences in mate value between the conditions where the distractors were of the same height, or slightly taller than the target. This is surprising, given that for the medium and large targets, being shorter than the surrounding distractors always affected the mate value negatively, whereas here, it does not seem to matter. A possibility is that the small target was being perceived as absolutely short anyway which affected the attractiveness negatively, and being slightly shorter than others did not affect the mate value anymore. This is reflected in the mean attractiveness ratings across all conditions, as the small target (M_S=3.64, SD_S=0.80) was rated as less attractive than either the medium (M_M=4.28, SD_M=0.78) or the large target (M_L=4.61, SD_L=0.83). Again, more research is necessary to investigate whether this pattern is robust.

Limitations

Our studies also have several limitations. While the distractors were manipulated in regard to their height, their overall size was changed, including their width. Therefore, when talking about contrast effects in regard to height, it is inevitably that it also a contrast in regard to overall size. Of course this was done deliberately, as otherwise the image would look unrealistic, and the change in overall size ensured that the BMI and body proportions were kept constant across all sizes. The observed effects can therefore not be attributed to these factors, and can only be related to overall height. However, bodily proportions do often change when humans are much taller or much shorter than average. Additionally, the targets in this study were all relatively muscular and healthy, with little visible body fat. To make broader claims of applicability, this should be considered in future studies, to investigate if the contrast illusion can also affect height and mate value perceptions if the body shape or proportions vary more. Of particular interest would also be to manipulate body proportions (e.g., leg length and the torso) separately and see if they have differential effects on these size illusions (Crossley et al. 2012).

Another limitation is the representativeness of our sample, as it mainly consisted of White European undergraduates (Henrich et al. 2010). As most research on mate preferences has focused on similar populations (e.g., Stulp et al. 2013b), it is likely that our results can be generalized to Western, undergraduate populations. However, as other studies have shown that preferences for height in Western samples are not necessarily universal (e.g., Sear 2010; Sear and Marlowe 2009; Sorokowski et al. 2011; Sorokowski and Butovskaya 2012), it is likely that our results do not generalize beyond Western student populations. Similarly, it is likely that our results do not generalize to homosexual individuals (see Valentova et al. 2014). In addition, while we could more directly control our stimulus image by relying on virtual models, the ecological validity of our studies is also limited and it remains to be seen whether these size illusions have measurable effects on actual behavior in the 'wild'.

While we did not find any interaction effects of the covariates with the conditions, it should be noted that our samples were rather homogenous. Across

both studies the age range was rather narrow, with 99% of the participants being between 18 and 27 years old. Although 49% were in a relationship vs. 51% single, only 3 participants (2%) were married. It is therefore possible that covariates such as age or marital status do come into effect when the participants are taken from a broader sample.

With regards to measurement we also assumed that a change in perceptions of height, attractiveness, dominance, and muscularity would result in a different perception of mate value. While previous literature strongly suggests an association between these traits and mate value (e.g., Courtiol et al. 2010; Frederick and Haselton 2007; Sadalla et al. 1987), it is possible that these traits are not strongly or equally related to mate value.

Finally, our research focused on a single trait, i.e., height, and the models presented in the stimulus images all had their faces blocked out. While male height is important for attractiveness judgments (e.g., Stulp et al. 2013b), studies suggest that the face might play a more important role for judging attractiveness than the body does (Currie and Little 2009; Re and Perrett 2012).

Future Research

Given the preliminary evidence that women can be fooled by height illusions when judging attractiveness, there is a great deal of future research possibilities to explore. One obvious option is to replicate the study with images of real humans instead of computer generated ones, and perhaps also presented in life-size. Although measures were taken to increase the realism of the stimulus images in the second study, using images of real people would be necessary to make any further claims regarding these stimuli. It might even be necessary to create further dynamic stimuli, involving 3D and movement (e.g., using point light methodology, Morris et al. 2013), to ensure better correspondence with the real world. In addition, it would also be worthwhile to examine whether men are equally fooled by height illusions when judging women, or when judging romantic rivals.

Another important avenue of research is a more direct investigation of the women's own height for these height illusions. As discussed in the introduction, while absolute height is important in mate choice, the relative height to a woman's own height plays an important role as well (e.g., Courtiol et al. 2010; Pawlowski 2003; Spuhler 1982; Stulp et al. 2013b). In our two studies, we found no evidence that one's own height would factor into the judgments made, but this could be simply due to our experimental setup. While the second study gave the participants an indication of the absolute height of the targets by including a background, our participants could not properly relate the perceived height to their own height. This is another avenue where life-size stimulus images might tell us more about how size illusions operate. Perhaps in this case, the participants' own height would have an impact on the perceptions.

Furthermore, as Gasparini et al. (2013) found that male guppies already use visual contrast effects to their advantage in mate choice by positioning themselves next to less colorful males if a female is present, it would be interesting to investigate whether men follow this strategy (unconsciously) as well. It is possible that men of shorter stature already position themselves strategically

next to others to increase their visibility, and perhaps also attractiveness, for example in a bar or night club.

Finally, further investigation is necessary to test whether the illusion still works if the target is surrounded, in different constellations, by both larger and shorter distractors. In Callander et al.'s (2012) experiment, the male crab was surrounded with two larger and two smaller distractors in both conditions. In the first condition, the crab was immediately surrounded by the larger ones, with the smaller ones further out, while in the second condition, it was the other way around, with the smaller distractors immediately next to the target. They observed the same size illusion as in the situation with only three crabs present (Callander et al. 2011). By using this design, it rules out the possibility that women simply always prefer the largest male in a given situation, thus lowering the attractiveness if surrounded by taller distractors. Since the total size distribution of the models is identical in every condition, the observed effects would truly be because of the contrast illusion created by the immediate neighbor, and not by the group's composition. Additionally, this would broaden the external validity of the observed effect, as in real life situations, people are usually not surrounded by only large or only small others, but rather by others of varying heights.

Concluding Remarks

In conclusion, the results of our two studies were fully in line with previous literature on contrast illusions and mate value from animal studies. The conclusions were two-fold, in that a) contrast illusions change the perceived height of targets, and b) the illusions affect the mate value of the target, while this is partially mediated by the height perceptions. To our knowledge, this was the first study to examine height contrast effects in human males and its effect on their mate value. The current findings indicate that if men can actually choose their social environment with regard to height, they could do so in a way that potentially increases their perceived mate value. By avoiding positioning themselves next to men who are taller than them, they could increase their relative attractiveness.

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Authors' contributions

The paper is based on the unpublished Master's Thesis of YSL, with TVP as his supervisor. The experiments were conceived and designed by TVP and YSL. YSL performed the experiments, analyzed the data, and wrote the paper. TVP supervised the whole process and gave feedback at every step.

Conflict of interest

The Authors declare that there is no Conflict of interest.

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